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Standard Specification for
QUENCHED AND TEMPERED ALLOY STEEL BOLTS FOR STRUCTURAL STEEL JOINTS[1]

This standard is issued under the fixed designation A 490; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

This specification has been approved for use by agencies of the Department of Defense for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This specification covers the chemical and mechanical requirements of quenched and tempered alloy steel bolts, $^1/_2$ to $1^1/_2$ in., incl, in diameter. These bolts are intended for use in structural joints that are made under the Specification for Structural Joints Using ASTM A 325 or A 490 Bolts[2] issued by the Research Council on Riveted and Bolted Structural Joints of The Engineering Foundation. The various types of bolts covered by this specification are:

1.1.1 *Type 1*—Bolts made of alloy steel, supplied in sizes $^1/_2$ to $1^1/_2$ in., inclusive, in diameter.

1.1.2 *Type 2*—Bolts made from what is generally described as low-carbon martensite steel, supplied in sizes $^1/_2$ to 1 in., inclusive, in diameter.

1.1.3 *Type 3*—Bolts $^1/_2$ to $1^1/_2$ in., inclusive, in diameter having atmospheric corrosion resistance and weathering characteristics comparable to that of the steels covered in Specifications A 588, A 242, and A 709 (these steels have atmospheric corrosion resistance approximately two times that of carbon structural steel with copper.

1.2 When the bolt type is not specified Type 1 shall be supplied. Type 3 may be supplied by the manufacturer, if agreed upon by the purchaser.

1.3 When atmospheric corrosion resistance and weathering characteristics are required, Type 3 bolts should be specified by the purchaser.

1.4 Suitable nuts are covered in Specification A 563. Unless otherwise specified, Grade DH heavy hex nuts shall be furnished for use with Type 1 and Type 2 bolts. Grade 2H heavy hex nuts, as specified in Specification A 194 are acceptable alternatives. Grade DH3 heavy hex nuts as specified in Specification A 563 shall be furnished for use with Type 3 bolts.

1.5 Hardened washers are covered in Specification F 436. Unless otherwise specified, Type 3 weathering steel washers shall be furnished when Type 3 bolts are specified.

1.6 This specification provides that heavy hex structural bolts shall be furnished unless other dimensional requirements are stipulated in the purchase inquiry and order.

NOTE 1—For quenched and tempered alloy steel bolts, studs, and other externally threaded fasteners with diameters greater than $1^1/_2$ in., but with similar mechanical properties, refer to Grade BD of ASTM Specification A 354, for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners.[5]

2. Applicable Documents

2.1 *ASTM Standards:*

A 194 Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service[3]

A 242 Specification for High-Strength Low-Alloy Structural Steel[4]

A 325 Specification for High-Strength Bolts for Structural Steel Joints[4]

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[1] This specification is under the jurisdiction of ASTM Committee F-16 on Fasteners, and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets, and Washers.

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[2] Published by the American Institute of Steel Construction, New York, N.Y.

[3] *Annual Book of ASTM Standards,* Part 1.

[4] *Annual Book of ASTM Standards,* Part 4.

A 370 Methods and Definitions for Mechanical Testing of Steel Products[5]

A 563 Specification for Carbon and Alloy Steel Nuts[3, 4]

A 588 Specification for High-Strength Low-Alloy Structural Steel with 50,000 psi Minimum Yield Point to 4 in. Thick[4]

A 709 Specification for Structural Steel for Bridges[4]

E 109 Dry Powder Magnetic Particle Inspection[6]

E 138 Wet Magnetic Particle Inspection[6]

F 436 Specification for Hardened Steel Washers for Use with High-Strength Bolts

2.2 *American National Standards:*[7]

B1.1 Unified Screw Threads

B18.2.1 Square and Hex Bolts and Screws

B18.2.2 Square and Hex Nuts

2.3 *Military Standard:*[8]

MIL-STD-105D Sampling Procedure and Tables for Inspection by Attributes

3. Definitions

3.1 Surface discontinuities as covered by this specification are defined as follows:

3.1.1 *crack*—a clean crystalline break passing through the grain boundary without inclusion of foreign elements.

3.1.2 *seam or lap*—a noncrystalline break through the metal which is inherent in the raw material.

3.1.3 *burst*—a break located at the periphery of the bolt head.

3.1.4 *acceptable quality level* (AQL)—as defined in MIL-STD-105D, the maximum percent defective that, for purposes of sampling inspection, can be considered satisfactory as the process average.

3.1.5 *process average*—as defined in MIL-STD-105D, the average percent defective of product as the time or original inspection. Original inspection is that first inspection of a particular quantity of product which is being reinspected after rejection and reconditioning.

4. Ordering Information

4.1 Orders for products under this specification shall include the following:

4.1.1 Quantity (number of pieces of bolts and accessories),

4.1.2 Name of products, including accessories such as nuts and washers when desired,

4.1.3 Dimensions, including nominal bolt diameter and length. For bolts of dimensional requirements other than heavy hex structural bolts (see 1.6) it is normally necessary to specify grip length,

4.1.4 Type of bolt (that is, Type 1, 2, or 3). Note that Type 1, 2, or 3 bolts may be supplied by the manufacturer when bolt type is not specified, if agreed upon by the purchaser,

4.1.5 ASTM designation and date of issue, and

4.1.6 Any special requirements.

NOTE 2—Two examples of ordering descriptions follow: (*1*) 1000 pieces, heavy hex structural bolts, each with two hardened washers, ASTM F 436, and one heavy hex nut, ASTM A 563 Grade DH, 1 by 4, ASTM A 490 dated ______. (*2*) 1000 pieces, heavy hex structural bolts, no nuts or washers, 7/8 by 2 1/4 Type 1, ASTM A 490 dated ______.

5. Materials and Manufacture

5.1 Steel shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

5.2 Type 1 bolts shall be heat treated by quenching in oil from above the transformation temperature. Type 2 and Type 3 bolts shall be quenched in a suitable liquid from above the transformation temperature. Type 1 and Type 3 bolts shall be tempered by reheating to a temperature of not less than 900°F (480°C). Type 2 bolts shall be tempered by reheating to a temperature of not less than 650°F (340°C). If heat treatment is performed by a subcontractor, the heat-treated material shall be returned to the manufacturer for testing.

5.3 Threads of bolts may be cut or rolled.

6. Chemical Requirements

6.1 Type 1 bolts shall be made from alloy steel conforming to the chemical composition requirements given in Table 1. The steel shall contain sufficient alloying elements to qualify it as an alloy steel.

NOTE 3—Steel is considered to be alloy, by the American Iron and Steel Institute, when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits:

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[5] *Annual Book of ASTM Standards*, Parts 1-5 and 10.

[6] *Annual Book of ASTM Standards*, Part 11.

[7] Available from American National Standards Institute, 1430 Broadway, New York, N. Y. 10018.

[8] Available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, Pa. 19120.

manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 %; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

6.2 Type 2 bolts shall be made from steel conforming to the chemical compositon requirements given in Table 2.

6.3 Type 3 bolts shall be made from steel conforming to the chemical composition requirements given in Table 2.

6.4 Product analyses may be made by the purchaser from finished material representing each lot of bolts. The chemical composition thus determined shall conform to the requirements given in Tables 1, 2, or 3, as applicable.

6.5 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for bolts.

7. Mechanical Requirements

7.1 Bolts less than three diameters in length shall have hardness values not less than the minimum nor more than the maximum hardness limits required in Table 4, as hardness is the only requirement.

7.2 Bolts 1 in. in diameter or less, other than those excepted in 7.1, shall be tested full size and conform to the minimum and maximum tensile strength and either proof load or alternative proof load requirements specified in Table 5.

7.3 Bolts larger than 1 in. in diameter, other than those excepted in 7.1, shall preferably be tested full size and when so tested, shall conform to the minimum and maximum tensile strength and either proof load or alternative proof load requirements as specified in Table 5. When equipment of sufficient capacity for full-size testing is not available, or when the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements of Table 6. In the event that bolts are tested by both full-size and by the machined test specimen methods, the full-size test shall govern if a controversy between the two methods exists.

7.4 For bolts on which hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event that there is controversy over low or high readings of hardness tests.

7.5 Surface hardness of bolts as taken at a maximum of 0.003 in. from the surface shall not be more than the equivalent of 3 points Rockwell C higher than the hardness taken at a distance of $^{1}/_{8}$ in. from the surface. Both hardness readings shall be taken on the same axial longitudinal section through the threaded length of the bolt, shall be taken at the same time, and the same hardness scale shall be used.

8. Dimensions

8.1 Unless otherwise specified, bolts shall conform to the dimensions for heavy hex structural bolts specified in ANSI B18.2.1.

8.2 Threads shall be the Unified Coarse Thread Series as specified in ANSI B1.1, and shall have Class 2A tolerances. When specified, 8 pitch thread series shall be used on bolts over 1 in. in diameter.

9. Quality Assurance of Mechanical Requirements

9.1 The manufacturer shall make sample inspections of every lot of bolts to ensure that properties of bolts are in conformance with the requirements of this specification. All bolts shall be inspected tested prior to shipment in accordance with one of the two quality assurance procedures described in 9.3 and 9.4, respectively. The manufacturer shall have the option of which procedure will be followed when furnishing bolts to any single purchase order.

9.2 The purpose of a lot inspection testing program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective, it is essential that following delivery the purchaser continue to maintain the identification and integrity of each lot until the product is installed in its service application.

9.3 *Production Lot Method:*

9.3.1 All bolts shall be processed in accordance with a lot-identification-control quality assurance plan. The manufacturer shall identify and maintain the integrity of each production lot of bolts from raw-material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

9.3.2 A production lot, for purposes of assigning an identification number and from which test samples shall be selected, shall consist of all bolts processed essentially together through all operations to the shipping container that are of the same nominal size, the same nominal length, and produced from the same mill heat of steel.

9.3.3 The manufacturer shall make tests for proof load, tensile strength (wedge test), and hardness of each lot of bolts. Alternatively, in accordance with 7.3, tests may be tensile strength, yield strength, reduction of area, elongation, and hardness.

9.3.4 From each production lot, the minimum number of tests of each required property shall be as follows:

Number of Pieces in Production Lot	Number of Specimens
800 and less	1
801 to 8 000	2
8 001 to 35 000	3
35 001 to 150 000	8
150 001 and over	13

9.3.5 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

9.3.6 Bolts shall be packed in shipping containers as soon as practicable following final processing. Shipping containers shall be marked with the lot identification number.

9.3.7 A copy of the inspection test report for each production lot from which bolts are supplied to fill the requirements of a shipment shall be furnished to the purchaser when specified in the order. Individual heats of steel need not be identified on the test report.

9.4 *Shipping Lot Method:*

9.4.1 In-process inspection during all manufacturing operations and treatments and storage of manufactured bolts shall be in accordance with the practices of the individual manufacturer.

9.4.2 Before packing bolts for shipment, the manufacturer shall make tests of sample bolts taken at random from each shipping lot. A shipping lot, for purposes of selecting test samples, is defined as that quantity of bolts of the same nominal size and same nominal length necessary to fill the requirements of a single purchase order.

9.4.3 The manufacturer shall make tests for proof load, tensile strength (wedge test), and hardness of each lot of bolts. Alternatively, in accordance with 7.3, tests may be tensile strength, yield strength, reduction of area, elongation, and hardness.

9.4.4 From each shipping lot, the minimum number of tests of each required property shall be as follows:

Number of Pieces in Shipping Lot	Number of Specimens
150 and less	1
151 to 280	2
281 to 500	3
501 to 1 200	5
1 201 to 3 200	8
3 201 to 10 000	13
10 001 and over	20

9.4.5 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

9.4.6 A copy of the inspection test report for each shipping lot shall be furnished to the purchaser when specified in the order. Individual heats of steel are not identified in the finished product.

10. Test Methods

10.1 Tests shall be conducted in accordance with Supplement III of Methods A 370.

10.2 Proof load testing of bolts tested in full size shall preferably be conducted in accordance with Method 1, Length Measurement, described in Supplement III of Methods A 370.

10.3 Bolts tested in full size shall be tested in accordance with the Wedge Test method described in Supplement III of Methods A 370. Fracture shall be in the body or threads of the bolt, without any fracture at the junction of the head and body.

10.4 Machined specimens shall be tested in accordance with the method described in S11.1.7, Supplement III of Methods A 370.

10.5 The speed of testing as determined with a free-running cross head shall be a maximum of 0.125 in./min for the bolt proof load determination, and a maximum of 1 in./min for the bolt tensile strength determination.

11. Magnetic Particle and Visual Inspection for Surface Discontinuities

11.1 Bolts shall be examined by magnetic particle inspection for longitudinal discontinuities and transverse cracks, and shall conform to an AQL of 0.25 when inspected in accordance with the sampling plan described in 11.4. Eddy-current inspection may be substituted, at the option of the manufacturer, for the 100 % magnetic particle inspection specified in 11.4.1 and 11.4.2, provided that the bolts, after eddy current inspection, are subsequently randomly sampled according to Table 7 and subjected to the magnetic particle inspection and acceptance requirements as described above. In the case of dispute, the magnetic particle test shall govern.

11.2 Bolts shall be examined visually for bursts and shall meet an AQL of 2.5 when inspected in accordance with the sampling plan described in 11.5.

11.3 A lot, for purposes of selecting a sample for magnetic particle or visual inspection, shall consist of all bolts of one type, having the same nominal diameter and length offered for inspection at one time. No lot shall contain more than 10 000 pieces.

11.4 *Longitudinal Discontinuities and Transverse Cracks:*

11.4.1 From each lot of bolts a representative sample shall be picked at random and magnetic particle inspected for longitudinal discontinuities and transverse cracks in accordance with Method E 109. (See Note 4). The sample size shall be as specified for an AQL of 0.25 in Table 7. If any defectives are found during inspection by the manufacturer all bolts in the lot shall be magnetic particle inspected and all defectives shall be removed and destroyed. If any defectives are found during inspection by the purchaser the lot shall be subject to rejection.

NOTE 4—Magnetic particle inspection may be conducted in accordance with Method E 138. For referee purposes Method E 109 shall be used.

11.4.2 Any bolt with a longitudinal discontinuity (located parallel to the axis of the bolt in the threads, body, fillet, or underside of head), with a depth normal to the surface greater than 0.03*D*, where *D* is the normal bolt size in inches, shall be considered defective. In addition, any bolt with a transverse crack (located perpendicular to the axis of the bolt in the threads, body, fillet, or underside of head), shall be considered defective.

NOTE 5—Magnetic particle indications of themselves shall not be cause for rejection. If in the opinion of the inspector the indications may be cause for rejection, a representative sample shall be taken from those bolts showing indications and shall be further examined by microscopical examination to determine whether the indicated discontinuities are in accordance with the specific limits.

11.5 *Bursts:*

11.5.1 From each lot of bolts a representative sample shall be picked at random and visually inspected for bursts. The sample size shall be as specified for an AQL of 2.5 in Table 7. If the number of defectives found during inspection by the manufacturer is greater than the acceptance number given in Table 7 for the sample size, all bolts in the lot shall be visually inspected and all defectives shall be removed and destroyed. If the number of defectives found during inspection by the purchaser is greater than the acceptance number given in Table 7 for the sample size, the lot shall be subject to rejection.

11.5.2 Any bolt with a burst having a width greater than 0.010 in. plus 0.025*D*, where *D* is the nominal bolt size in inches, shall be considered defective.

12. Inspection

12.1 If the inspection described in 12.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

12.2 The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities, without charge, to satisfy him that the material is being furnished in accordance with this specification. All tests (except product analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

13. Rejection

13.1 Unless otherwise specified, any rejection based on requirements specified herein shall be reported to the manufacturer within 30 working days from the receipt of the material by the purchaser.

14. Certification

14.1 When specified on the order the manufacturer shall furnish the test reports described in 9.3.7 or 9.4.6, depending on whether the bolts are furnished by the production lot or shipping lot method.

15. Marking

15.1 Bolt heads shall be marked A 490, and shall also be marked to identify the manufacturer. Markings may be either raised or depressed, at the option of the manufacturer.

15.2 In addition to the markings required in 15.1, Type 2 bolts shall be marked with six radial lines 30 deg apart.

15.3 In addition to the markings required in 15.1, Type 3 bolts shall have the A 490 underlined, and the manufacturer may add other distinguishing marks indicating that the bolt is atmospheric corrosion resistant and of a weathering type.

TABLE 1 Chemical Requirements for Type 1 Bolts

Element	Heat Analysis, %	Product Analysis, %
Carbon		
For sizes through $1^{3}/_{8}$ in.	0.30–0.48	0.28–0.50
For size $1^{1}/_{2}$ in.	0.35–0.53	0.33–0.55
Phosphorus, max	0.040	0.045
Sulfur, max	0.040	0.045

TABLE 2 Chemical Requirements for Type 2 Bolts

Element	Heat Analysis, %	Product Analysis, %
Carbon	0.15–0.34	0.13–0.37
Manganese, min	0.70	0.67
Phosphorus, max	0.040	0.048
Sulfur, max	0.050	0.058
Boron, min	0.0005	0.0005

TABLE 3 Chemical Requirements for Type 3 Bolts

Element	Heat Analysis, %	Product Analysis, %
Carbon	0.20–0.53	0.19–0.55
Manganese, min	0.40	0.37
Phosphorus, max	0.040	0.045
Sulfur, max	0.050	0.055
Copper, max	0.60	0.63
Chromium, min	0.45	0.42
Nickel, min	0.20	0.17
or		
Molybdenum, min	0.15	0.14

TABLE 4 Hardness Requirements for Bolts

	Hardness Number			
Bolt Size, in.	Brinell		Rockwell C	
	min	max	min	max
$^{1}/_{2}$ to $1^{1}/_{2}$, incl	311	352	33	38

TABLE 5 Tensile Requirements for Full-Size Bolts

Bolt Size, Threads per Inch, and Series Designation	Stress Area,[A] in.^{2} (cm^2)	Tensile Load,[B] lbf(kN)		Proof Load,[B] lbf(kN)	Alternative Proof Load,[B] min, lbf(kN)
		min	max	Length Measurement Method	Yield Strength Method
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
1/2-13 UNC	0.142 (0.92)	21 300 (95)	24 150 (107)	17 050 (76)	18 500 (82)
5/8-11 UNC	0.226 (1.46)	33 900 (151)	38 400 (171)	27 100 (121)	29 400 (131)
3/4-10 UNC	0.334 (2.15)	50 100 (223)	56 800 (253)	40 100 (178)	43 400 (193)
7/8-9 UNC	0.462 (2.98)	69 300 (308)	78 550 (349)	55 450 (247)	60 100 (267)
1-8 UNC	0.606 (3.91)	90 900 (404)	103 000 (458)	72 700 (323)	78 800 (351)
1 1/8-7 UNC	0.763 (4.92)	114 450 (509)	129 700 (577)	91 550 (407)	99 200 (441)
1 1/8-8 UN	0.790 (5.10)	118 500 (527)	134 300 (597)	94 800 (422)	102 700 (457)
1 1/4-7 UNC	0.969 (6.25)	145 350 (647)	164 750 (733)	116 300 (517)	126 000 (560)
1 1/4-8 UN	1.000 (6.45)	150 000 (667)	170 000 (756)	120 000 (534)	130 000 (578)
1 3/8-6 UNC	1.155 (7.45)	173 250 (771)	196 350 (873)	138 600 (617)	150 200 (668)
1 3/8-8 UN	1.233 (7.95)	185 000 (823)	209 600 (932)	148 000 (658)	160 300 (713)
1 1/2-6 UNC	1.405 (9.06)	210 750 (937)	238 850 (1062)	168 600 (750)	182 600 (812)
1 1/2-8 UN	1.492 (9.63)	223 800 (996)	253 650 (1128)	175 050 (779)	194 000 (863)

[A] The stress area is calculated as follows:

$$A_s = 0.7854\,[D - (0.9743/n)]^2$$

where:

A_s = stress area, in.^{2},
D = nominal bolt size, and
n = threads per inch.

[B] Loads tabulated and loads to be used for tests of full size bolts larger than 1 1/2 in. in diameter are based on the following:

Bolt Size	Column 3	Column 4	Column 5	Column 6
1/2 to 1 1/2 in., incl	150 000 psi (1035 MPa)	170 000 psi (1170 MPa)	120 000 psi (825 MPa)	130 000 psi (895 MPa)

TABLE 6 Tensile Requirements for Specimens Machined from Bolts

Bolt Size, in.	Tensile Strength, psi (MPa)		Yield Strength (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50 mm, min, %	Reduction of Area, min, %
	min	max			
1/2 to 1 1/2 in., incl	150 000 (1035)	170 000 (1170)	130 000 (895)	14	40

TABLE 7 Sample Sizes and Acceptance Numbers for Inspection of Longitudinal Discontinuities, Transverse Cracks and Bursts

Lot Size	0.25 AQL		2.5 AQL	
	Sample Size[A, B]	Acceptance Number[A]	Sample Size[A, B]	Acceptance Number[A]
1 to 150	50	0	5	0
151 to 500	50	0	20	1
501 to 1 200	50	0	32	2
1 201 to 3 200	50	0	50	3
3 201 to 10 000	50	0	80	5

[A] Sample sizes and acceptance numbers are extracted from "Single Sampling Plan for Normal Inspection" Table 11A, MIL-STD-105D.

[B] Inspect all bolts in the lot if lot size is less than sample size.

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